S.A.V and winter: rapid preparation of salt brine solutions.
New technologies at the service of winter road maintenance

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ABSTRACT

The Rapid Dissolver is result of our experience, based on the use of special Venturi nozzles, with tanks containing a hot calcium chloride solution (60° - 70°C) to be spread on roads during winter maintenance operations. The Venturi nozzles have the ability to push a quantity of fluid via automatic suction (according to nozzle diameter and pressure) that is 6 to 8 times greater than that produced by the nozzle itself. This principle was then extended to the production of aqueous solutions with products commonly used for winter road maintenance in addition to calcium chloride, such as sodium chloride and magnesium chloride used for the humidification of de-icers distributed on the road by specially equipped spreaders. This was followed by the design of a special "dissolution tank" in fibreglass (a material totally insensitive to corrosion) having a capacity of 10 cu m or 5 cu m to be installed in a fixed position anchored to the floor in the location best suited for its operation.

1. INTRODUCTION

Some preliminary background on SAV is needed to understand who we are and what we do in light of the discussion to follow.
SAV, the Società Autostrada Valdostane, a concessionaire of ANAS established in 1962, and of which I am General Manager, built the Quincinetto-Aosta motorway in the years from 1965-1970.
The motorway was designed to link the existing motorway system of the Po River Valley with the Alpine tunnels of Great St. Bernard, opened to traffic on March 19th, 1964 and Mont Blanc, opened on July 16th, 1965. The resulting infrastructure was fundamental to the development of tourism in Valle d'Aosta, as it made it possible to reach popular destinations in a significantly reduced amount of time and in greater safety. In 1996, the infrastructure was integrated into the Aosta ring road system. This, together with the motorway constructed by RAV, completed the connection with the Mont Blanc Tunnel, and again in 2001, with the A5/S.S. 27 Great St. Bernard access road, which bypassed the city of Aosta and facilitated entry to the Great St. Bernard Tunnel and mountain pass of the same name.
To the present, and I refer to data made available over the last 12 months, the above motorway system carries a daily traffic of 24,400 vehicles, of which 19,800 are light vehicles and 4,600 heavy vehicles. Each day these vehicles move through the SAV network accruing a total of about 932,000 km, with light vehicles accounting for 731,000 km and heavy vehicles for 201,000 km.

2. SAV AND WINTER

This infrastructure is situated, develops and interacts with the Alpine orography of Valle d'Aosta, a complex formation of mountains subjected to relentlessly harsh weather conditions in winter. Given such a difficult geographic-meteorological context, S.A.V. has been forced to adopt innovative technologies so that motorists are guaranteed high safety standards even during the winter season. First among these technologies are the "Self Service" automated salt storage facilities, which allow a single operator to independently and rapidly withdraw a calculated quantity of de-icer in order to perform preventive treatment or snow removal.

Figure 1 - Nus Maintenance Station

The Nus Maintenance Station (Figure 1) is equipped with two salt storage facilities totalling a capacity of 1000 tonnes (500 tonnes of fine recrystallized salt having a fine granulometry of 0-1 mm for preventive application and 500 tonnes of salt with a larger granulometry of 0-5 mm for snow removal treatment) and a facility for the storage of calcium chloride and related plant for the automated preparation of liquid solutions. Completing the facility is a sizeable fleet of machines fitted with snow removal blades and spreaders, and an innovative patented machine (Figure 2) for the rapid preparation of calcium chloride solutions at high temperature (exploiting the exothermic reaction the calcium chloride produces upon its solubilization in water) and the pressurized application of these solutions onto the road.

Figure 2 - Machine for the preparation and application of high-temperature pressurized solutions to the road.

Figure 3 - Image of hot solution application taken with a thermographic camera.

The machine includes a patented system for the extremely rapid preparation of solutions, featuring internal hydraulic circuits fitted with Venturi nozzles that intensify the movement of the liquid inside the tank and thus enable the instant dissolution of the calcium chloride in water. Approximately 5 minutes are needed to prepare over 10,000 litres of salt brine solution. The insulated fibreglass tank "harnesses" the heat produced upon the dissolving of the calcium chloride in water and maintains a supply of the solution at maximum temperature (55- 70 °C) for an extended period until it is applied to the road.


Figure 4 - Bar with rectilinear high-pressure jets

A spray bar fitted with nozzles for rectilinear jet spraying (Figure 4) allows the solution to be applied at a high pressure (7 bar). The result is a triple effect -- chemical, thermal (Figure 3) and mechanical (Figure 5) -- which proves much more effective on pavement covered with packed snow, ice, freezing rain, etc. compared to traditional spreading systems.


Figure 5 - Chemical-thermal-mechanical effect and "cutting" effect on packed snow

3. THE SHORT-TERM FUTURE

The same technology for the rapid preparation of salt brine solutions described above is now available for stationary plants and will be object of a possible acquisition in the future by Agristrade as a way to accelerate and render this production process even more efficient. As mentioned above, it is based on a special liquid movement system fitted with Venturi nozzles (Figure 6). The Venturi nozzles have the ability to push a quantity of fluid via automatic suction (according to nozzle diameter and pressure) that is 6 to 8 times greater than that produced by the nozzle itself.

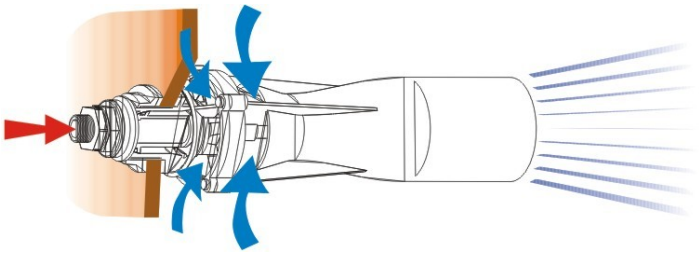

Figure 6 - Venturi agitator

Completing the equipment is a special 15 kW electrical pump in an anti-corrosion material along with the Venturi nozzles (18) correctly positioned, as well as separators of any mud or impurities from the undissolved salt (Figure 7).

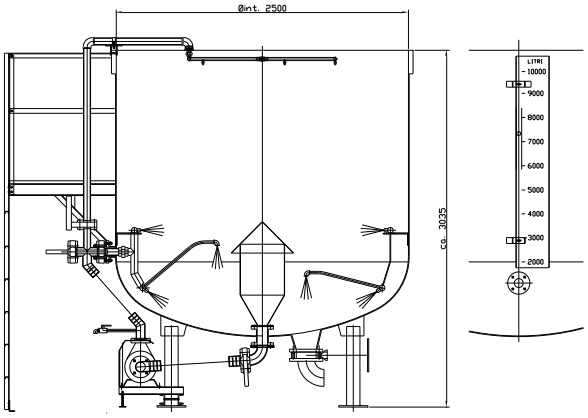

Figure 7 - Dissolution tank

Up to now the market offered systems (Figure 8) that could produce the brine solutions with only some of the more commonly utilized road de-icers and at an extremely reduced hourly production. This new system, instead, can prepare without distinction liquid solutions with all available de-icers (sodium chloride, calcium chloride and magnesium chloride) with superior performance.

Figure 8 - 10,000 litre preparation tank coupled with a storage silo

From the previous 2500-3000 litres/h -- average hourly production declared for the preparation of sodium chloride solutions -- now up to 10,000 litres can be produced in a half hour, equivalent to 20,000 litres/h, thus at a 6-8 times faster rate.

Not to be underestimated is the possibility to use lower grade, more inexpensive de-icers, such as sea salt or rock salt rich in insoluble substances, thanks to a special filtration and decanting system (Figure 9). The system enables the separation of the insoluble parts, their collection and removal from the preparation tank.

Figure 9 - Separation and disposal of insoluble residues

4. RESULTING ADVANTAGES

- rapid preparation of the salt brine solutions, leading to:
  - extreme speed in application to the road and in replenishing strategic supplies in case of severe weather events
  - lower personnel costs due to their reduced use for such operations
  - reduced capacity and dimensions of preparation systems and storage, hence minimum space to be dedicated for these facilities

- multi-functionality
  The new system solubilizes all road salts commonly used for winter road maintenance. A single plant carries out the preparation of different types of solution for a wide range of road maintenance interventions, e.g. application via sprayers of liquid solutions directly to the pavement, application of humidified salt, etc.

- production of "clean" solutions
  The special system for separation and removal of a large part of insoluble residues present in almost all salts on the market (with some exceptions, i.e. recrystallized fine salt) permits the preparation of "clean" solutions. This leads to a drastic reduction in the risk of clogging road application systems both in sprayer tanks and in the spreaders fitted with salt humidification systems.

- costs of producing solutions is much lower than purchasing pre-packaged solutions.

The new system can be equipped with load cell weighing system for the fully automated production of brine solutions, with the de-icer to be solubilized coming from the storage silo for example: or in the version with manual loading of the solution by means of big bags of 1000 kg, sacks of 25 kg or picked up from storage in bulk form using a dozer.

As an option, solenoid valves can be installed in order to enable the fully automated control of the fluid movement. This allows the facility to manage in complete autonomy the load of the water and the storage of the solution in the dedicated tanks upon termination of production and to resume new cycles, a process that leads to an increase in production capacity. Completing the equipment is a maximum level sensor that can be installed with an overload control that alerts the water supply solenoid valve when the maximum limit of fluid allowed inside the tank is exceeded.

This fully modular system can prepare brine solutions in manual, semi-automatic or fully automatic mode. This last option, as briefly mentioned, also allows the possibility to pre-input the production in order to have solutions chemically ready (i.e., at the correct concentration) and thermally ready (i.e., at maximum temperature) in case of programmed maintenance with personnel who start work just when road spreading operations commence.

5. ECONOMIC ANALYSIS

We offer a brief economic analysis regarding the use of calcium chloride solutions that have been pre-packaged or self-produced. Similar observations can be made for sodium chloride solutions with due proportions calculated and costs put into context.

In Italy, almost all calcium chloride solutions are purchased ready mixed and are stored at maintenance stations inside tanks that can contain up to 140m^3.

A calcium chloride solution at a 27% concentration has a weight of 1260kg/m^3 of which approx. 343kg/m^3 is actual calcium chloride, representing the "active" ingredient of the solutions, and the remaining part water and undissolved parts. It goes without saying that over 70% of the weight of the material transported related to the purchase of calcium chloride solution are components readily available at the sites where the solution is to be used.

This means that a significant part of the transport costs can be saved by transporting only what is unavailable and indispensable for the utilization of the solution, i.e., the calcium chloride.

The cost of 1t of 27% calcium chloride solution is €117.00. Let us reconstruct the cost of 1t of self-produced calcium chloride:
1t of granular $CaCl_2$ (at a 94-98% concentration) costs €265.00/t; the cost for water is negligible.

To produce 1t of solution we need 0.712T of H_2O and 0.287T of $CaCl_2$ (with the cited characteristics). This means that the total cost of 1t of self-produced solution utilizing pure granular $CaCl_2$ at a concentration of 94-98% is about €76.

This cost difference, considering also the demand for winter road maintenance solutions, makes the infrastructure cost of the facilities quickly amortizable, thus economically advantageous and profitable in the other ways mentioned very shortly after installation.

For example, on small companies managing Italian motorway network, 726T of solution distributed on the road yearly, is an average quantity. This entails a savings of €29,766.00/year considering just the advantage of self-production. Other benefits to be

taken into account are the fewer trucks on the motorway and the important fact that in case of an intense snowfall the self-production of solution avoids the risk of a failure in the distribution of the pre-packaged solutions and a consequent worsening of the of road management during emergency situations.